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Tokuda

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(54) **FIXING DEVICE HAVING A FUSER PAD OF VARYING THICKNESS AND IMAGE FORMING APPARATUS INCORPORATING SAME**

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USPC 399/328–333
See application file for complete search history.

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(57) **ABSTRACT**

A fixing device includes a rotatable, flexible fuser belt, a fuser pad, and a pressure member. The rotatable, flexible fuser belt is looped into a generally cylindrical configuration. The fuser pad extends in an axial, longitudinal direction thereof inside the loop of the fuser belt. The pressure member extends in the axial direction opposite the fuser pad with the fuser belt interposed between the fuser pad and the pressure member. The pressure member presses against the fuser pad through the fuser belt in a load direction to form a fixing nip therebetween, through which a recording medium is conveyed in a conveyance direction. The fuser pad includes an upstream section, a midstream section, and a downstream section having differing thicknesses is a load direction arranged in series from upstream to downstream in the conveyance direction.

17 Claims, 8 Drawing Sheets

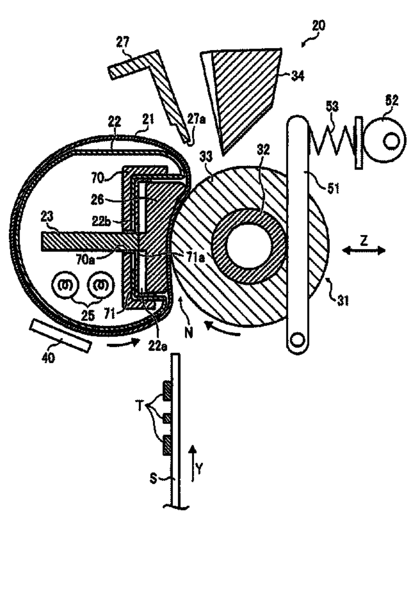

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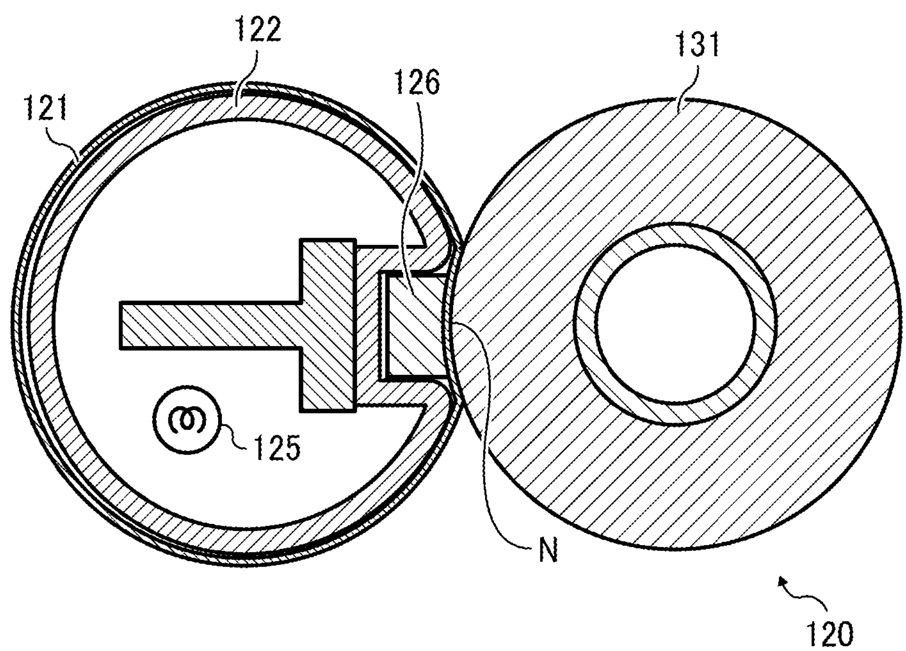
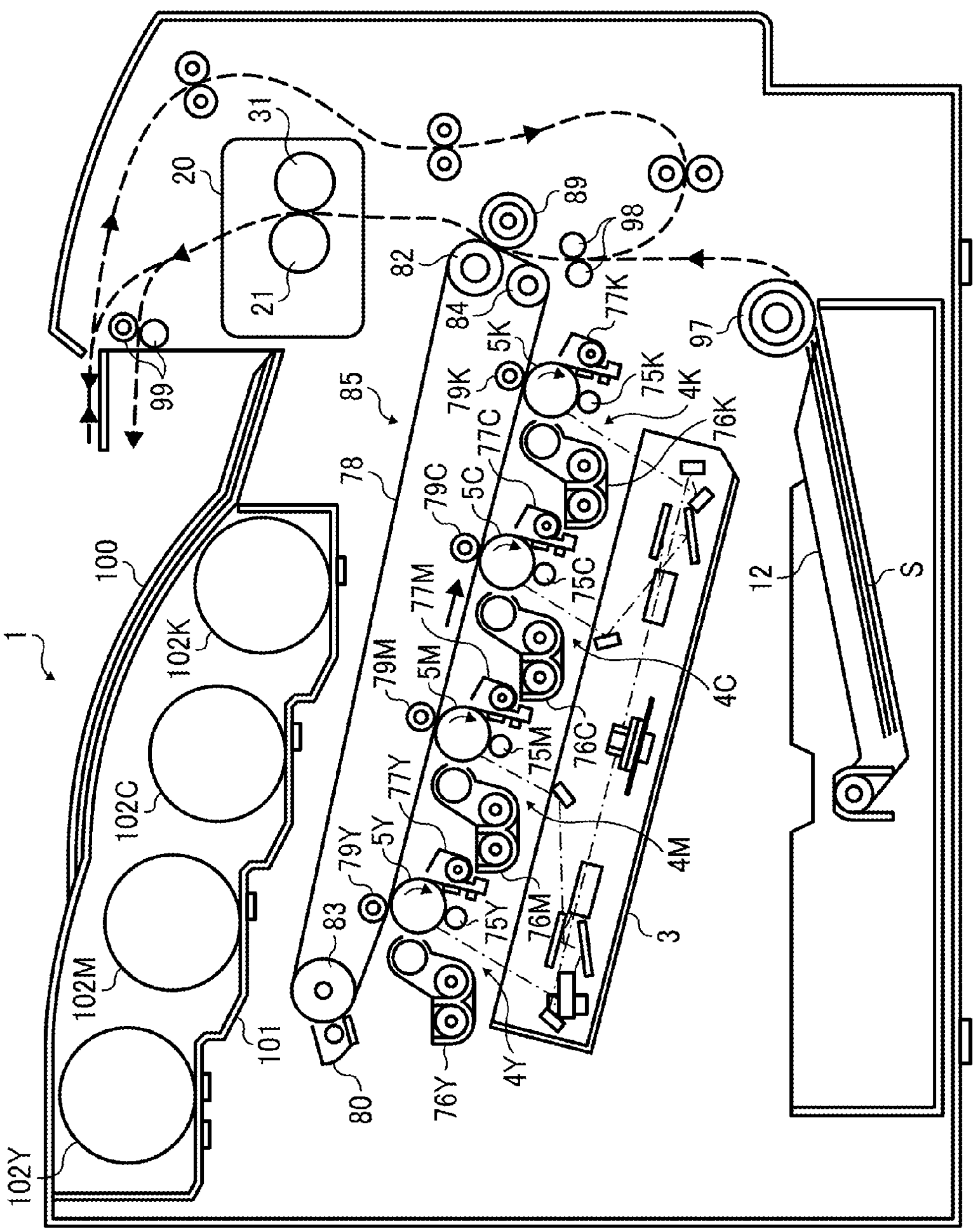
FIG. 1
BACKGROUND ART

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102M
102C
102K
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80
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99
12
S
3
4Y
4M
4C
4K
5Y
5M
5C
5K
75Y
75M
75C
75K
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77C
77K
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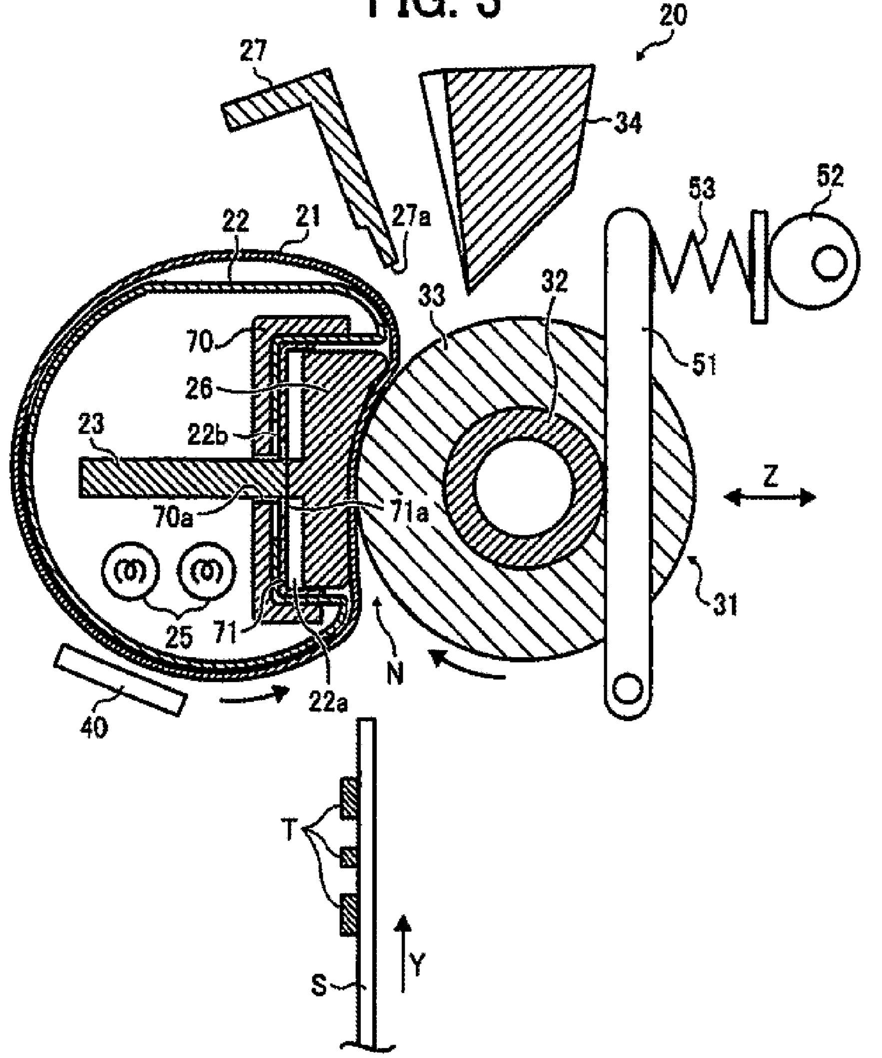
79M
79C
79K

FIG. 2

FIG. 3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27
34
27a
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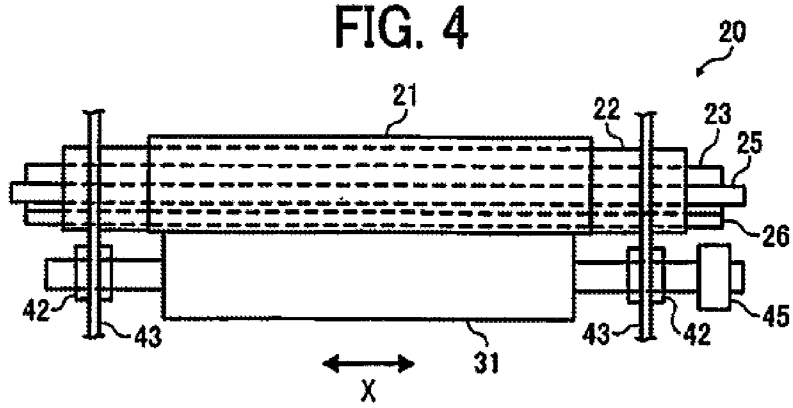
52
22
21
33
32
70
51
26
23
22b
Z
70a
71a
25
71
31
N
22a
40
T
Y
S

FIG. 4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21
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45
31
X

FIG. 5

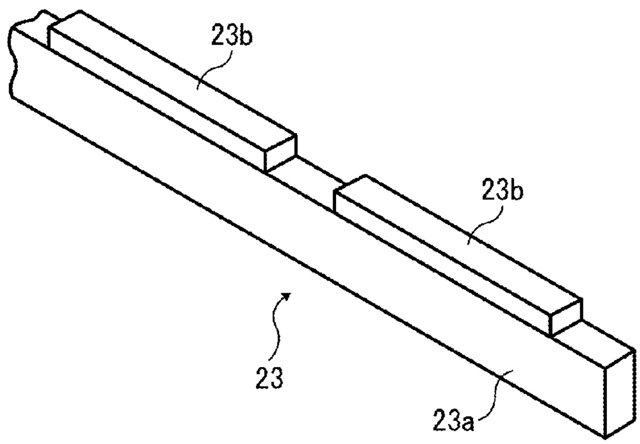


FIG. 6

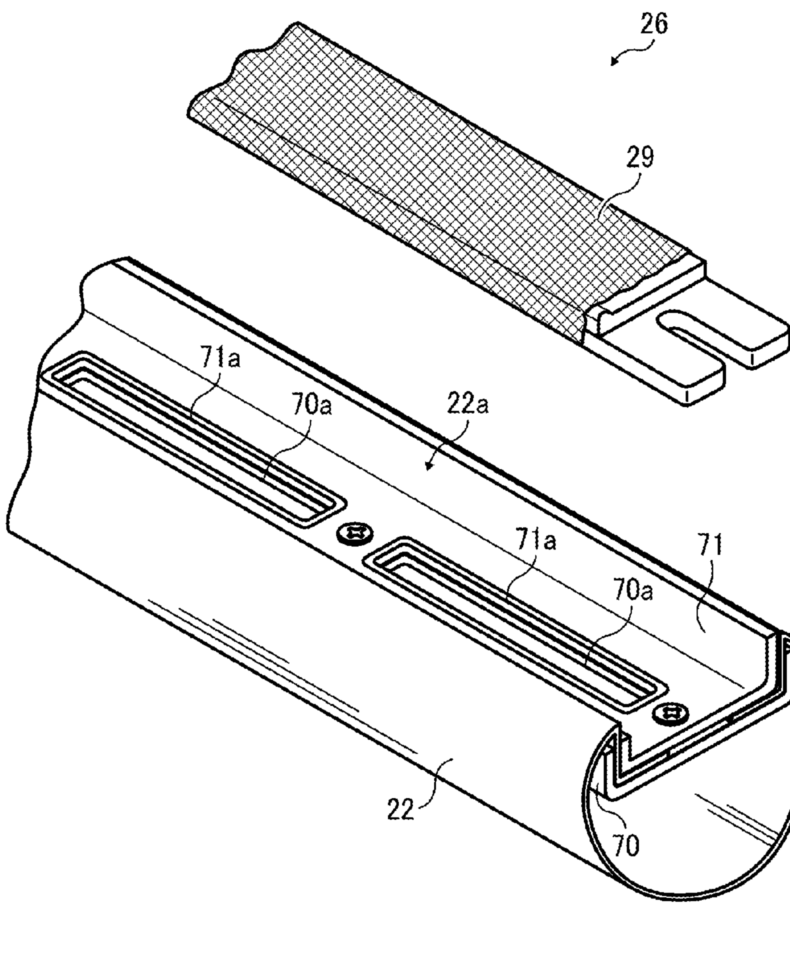


FIG. 7

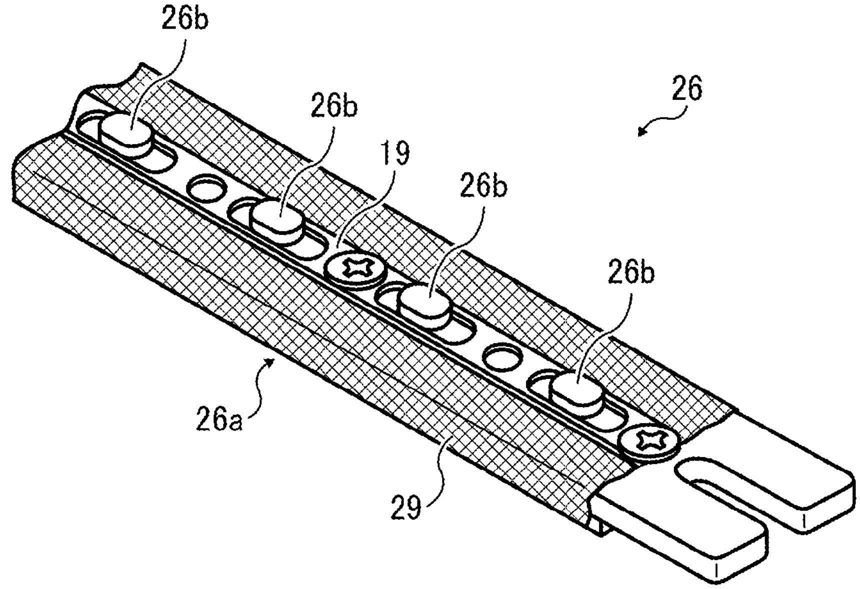


FIG. 8

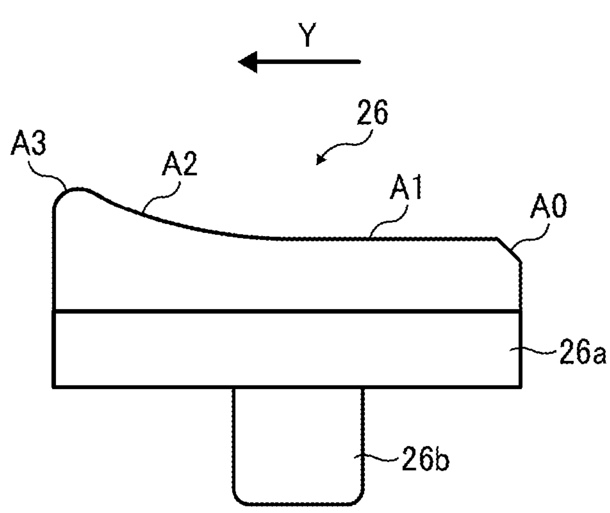
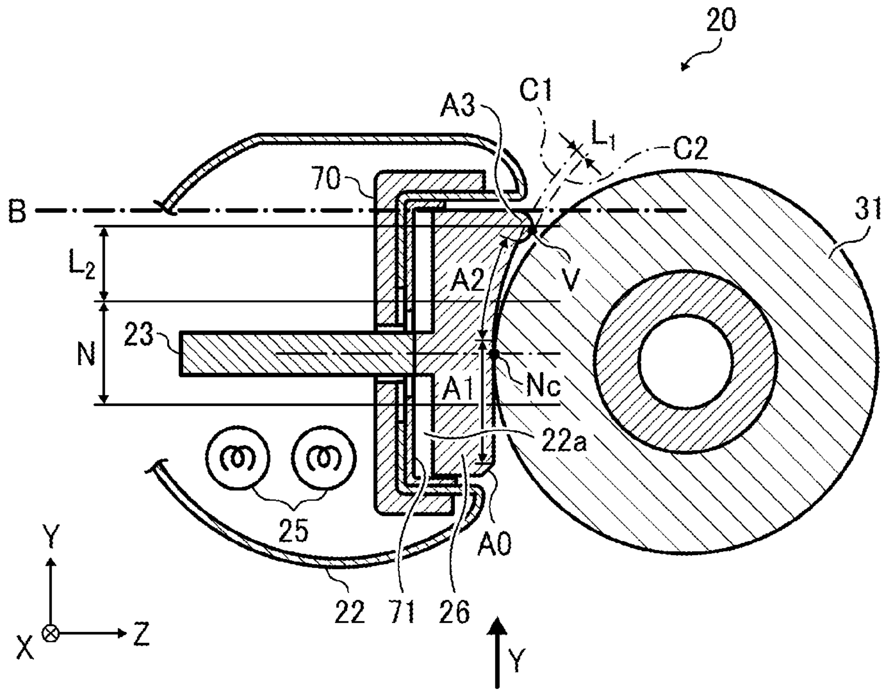
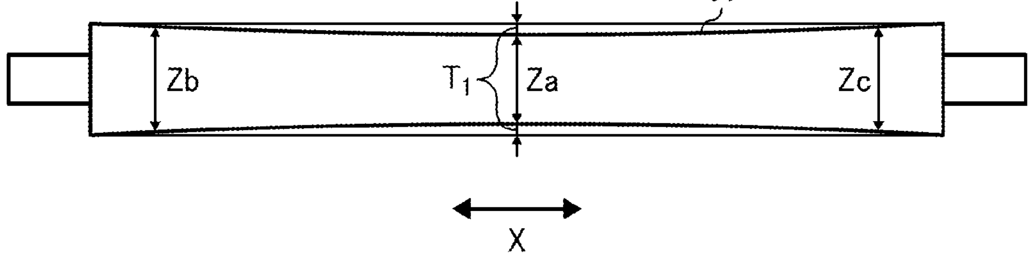


FIG. 9



20
A3
C1
L_1
C2
70
B
31
L_2
A2
V
23
N
A1
Nc
22a
25
Y
A0
22
71
26
X
Z
Y

FIG. 10



31
Zb
T_1
Za
Zc
X

FIG. 11A

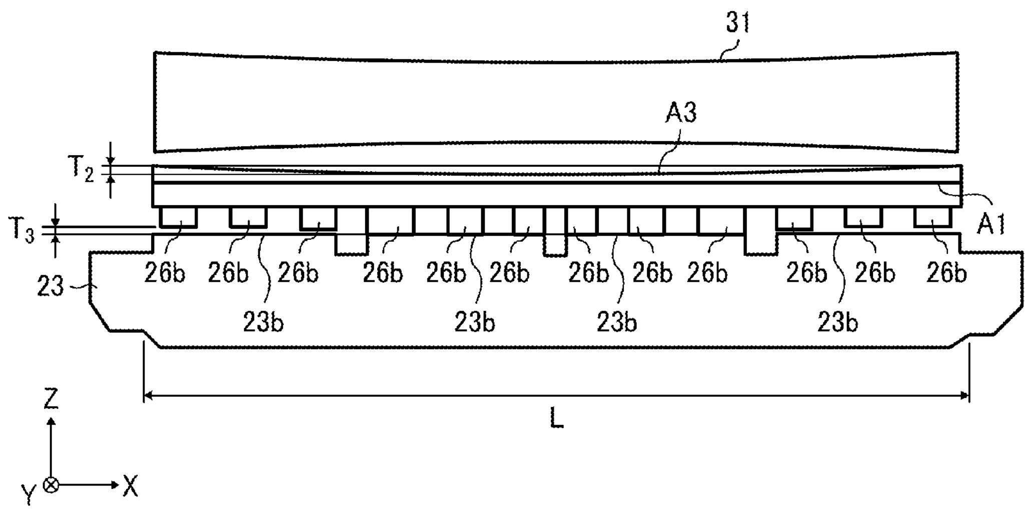


FIG. 11B

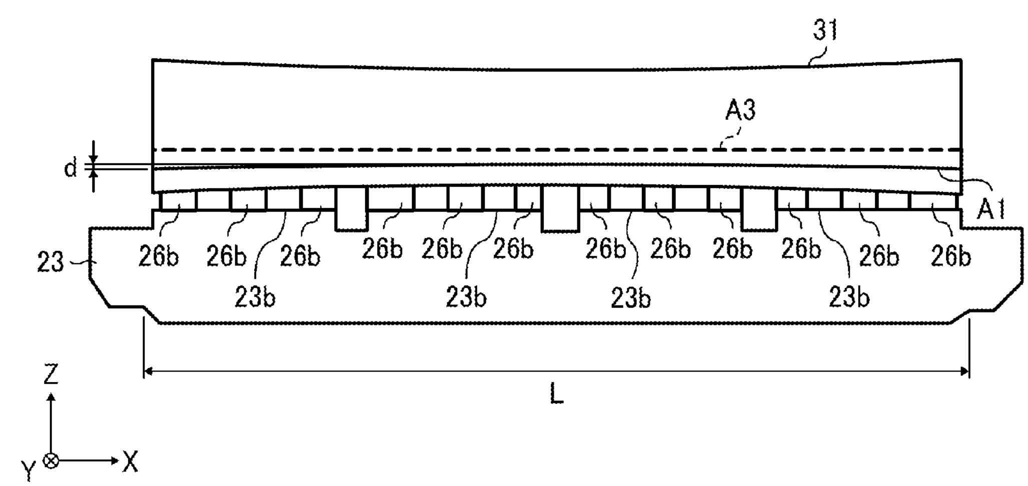


FIG. 12

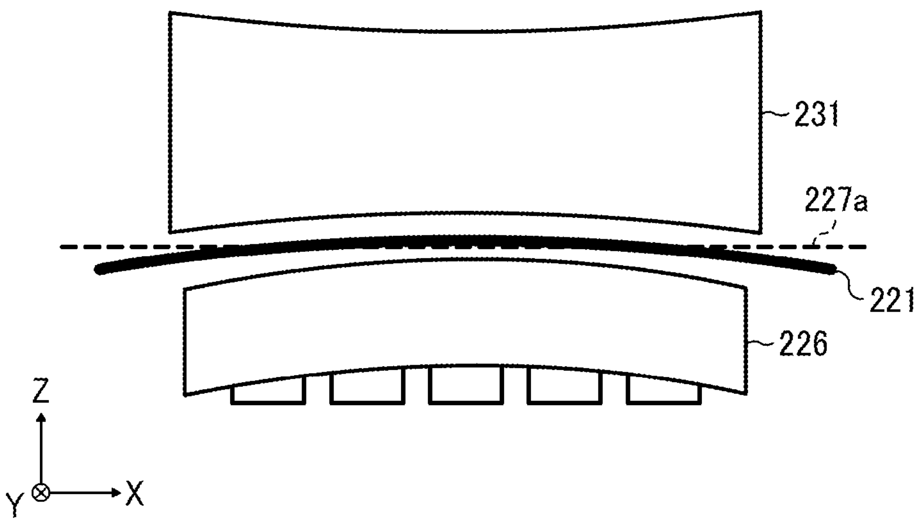
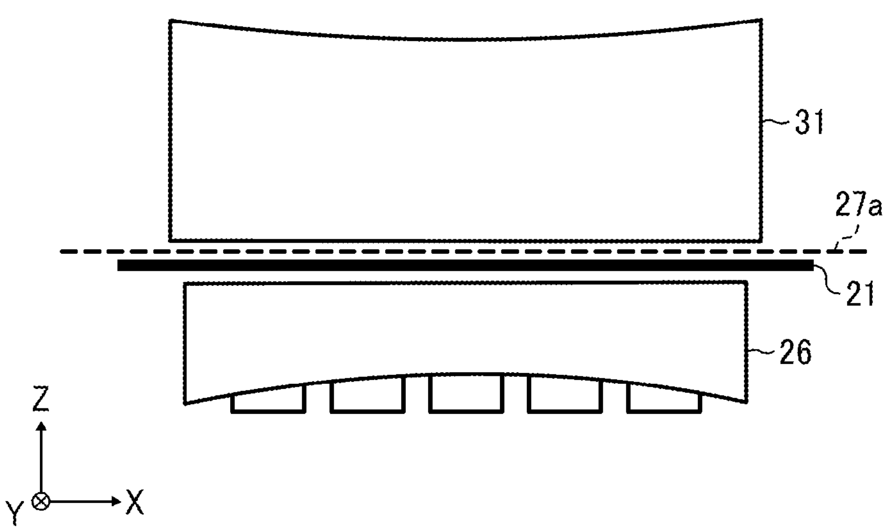


FIG. 13



FIXING DEVICE HAVING A FUSER PAD OF VARYING THICKNESS AND IMAGE FORMING APPARATUS INCORPORATING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

The present patent application claims priority pursuant to 35 U.S.C. §119 from Japanese Patent Application Nos. 2012-128603 and 2013-105849, filed on Jun. 6, 2012 and May 20, 2013, respectively, each of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

1. Technical Field

The present invention relates to a fixing device and an image forming apparatus incorporating the same, and more particularly, to a fixing device that employs a belt for fixing images, and an image forming apparatus incorporating such a fixing device.

2. Background Art

In electrophotographic image formation, an image is formed by attracting toner particles to an electrostatic latent image on a photoconductive surface for subsequent transfer to a recording medium such as a sheet of paper. After transfer, the imaging process is followed by a fixing process using a fixing device, which permanently fixes the toner image in place on the recording medium to obtain a print output.

One specific type of the fixing device is a roller-based fixing device employing a pair of cylindrical fixing rollers, one being a fuser roller subjected to heating, and the other being a pressure roller disposed opposite the fuser roller. The pressure roller presses against the fuser roller to form a fixing nip therebetween, through which the recording sheet is conveyed. At the fixing nip, the fuser roller heats the incoming sheet to fuse and melt the toner particles, while the pressure roller presses the sheet against the fuser roller to cause the molten toner to set onto the sheet surface.

Another, more thermally efficient fixing device employs a flexible, looped fuser belt, instead of the fuser roller, subjected to heating and disposed opposite the pressure roller. Compared to the roller-based configuration, the belt-based fixing device does not require significant time to heat the fuser assembly to an operational temperature upon start-up, owing to a relatively low heat capacity of the fuser belt lower than that of the fuser roller.

FIG. **1** is an axial, cross-sectional view of an exemplary belt-based fixing device **120**.

As shown in FIG. **1**, the fixing device **120** includes a fuser belt **121** looped into a generally cylindrical configuration, a fuser pad **126** disposed inside the loop of the belt **121**, and a pressure roller **131** pressing against the fuser pad **126** via the belt **121** to form a fixing nip N therebetween. Also included is a stationary, tubular pipe **122**, formed of metal or heat conductive material, around which the fuser belt **121** is supported or guided during rotation. A heater **125** is disposed inside the tubular pipe **122** to radiate heat to the pipe **122**, which in turn conducts heat to the fuser belt **121** entrained around the pipe **122**.

One problem associated with the belt-based fixing device is that the recording medium, in particular, a sheet of paper that contains relatively large amount of moisture, curls or bends toward the fuser belt in a manner similar to that of a bimetallic strip. Such curling causes the recording sheet to eventually wind or wrap around the fuser belt upon exiting the fixing nip, leading to malfunction or even failure of the fixing process.

To counteract the problem, a technique has been proposed that employs an anti-curling member downstream from the fixing nip to prevent curling and concomitant winding of the recording sheet around the fuser belt.

According to this method, the fuser belt comprises a looped film supported around a guide member within which a heater is accommodated. The anti-curling member is a protrusion formed integral with the guide member, which contacts the recording sheet upon exiting the fixing nip, so that the outgoing sheet moves away from the fuser belt. Disposed downstream from the anti-curling member is a sheet stripper, which defines a longitudinal edge adjacent to and out of contact with the fuser belt to engage the leading edge of the recording sheet for separating it away from the fuser belt.

BRIEF SUMMARY

Exemplary aspects of the present invention are put forward in view of the above-described circumstances, and provide a novel fixing device.

In one exemplary embodiment, the fixing device includes a rotatable, flexible fuser belt, a fuser pad, and a pressure member. The rotatable, flexible fuser belt is looped into a generally cylindrical configuration. The fuser pad extends in an axial, longitudinal direction thereof inside the loop of the fuser belt. The pressure member extends in the axial direction opposite the fuser pad with the fuser belt interposed between the fuser pad and the pressure member. The pressure member presses against the fuser pad through the fuser belt in a load direction to form a fixing nip therebetween, through which a recording medium is conveyed in a conveyance direction. The fuser pad includes an upstream section, a midstream section, and a downstream section arranged in series from upstream to downstream in the conveyance direction. The upstream section defines a generally planar surface along which the recording medium is introduced into the fixing nip. The midstream section defines an inwardly curved, concave surface that conforms to an outer circumferential surface of the pressure member. The downstream section defines a protruding surface that protrudes outward toward the pressure member while located apart from the pressure member. The pressure member comprises a concave roller whose diameter gradually increases by a first amount of taper from a longitudinal center toward both longitudinal ends thereof in the axial direction. The downstream section of the fuser pad has a thickness in the load direction which gradually increases by a second amount of taper, corresponding to the first amount of taper, from a longitudinal center toward both longitudinal ends thereof in the axial direction.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** is an axial, cross-sectional view of an exemplary belt-based fixing device;

FIG. **2** schematically illustrates an image forming apparatus according to one embodiment of this patent specification;

FIG. **3** is an end-on, axial view of a fixing device according to one embodiment of this patent specification;

FIG. **4** is a top plan view of the fixing device of FIG. **3**;

FIG. **5** is a perspective view of a reinforcing member before assembly into the fixing device of FIG. **3**;

FIG. **6** is a perspective view of a heat pipe and a fuser pad before assembly into the fixing device of FIG. **3**;

FIG. **7** is another perspective view of the fuser pad of FIG. **6**;

FIG. **8** is a side elevational view of the fuser pad of FIG. **6**;

FIG. **9** is another end-on, axial view of the fixing device of FIG. **3**, shown with a fuser belt omitted for clarity;

FIG. **10** is a schematic view of a pressure member before assembly into the fixing device of FIG. **3**;

FIGS. **11**A and **11**B are elevational views of the fuser pad, the pressure member, and the reinforcing member, shown in their respective positions with the fuser belt omitted for clarity;

FIG. **12** is a schematic view of an exemplary fixing device; and

FIG. **13** is a schematic view of the fixing device according to one or more embodiments of this patent specification.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In describing exemplary embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve a similar result.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, exemplary embodiments of the present patent application are described.

FIG. **2** schematically illustrates an image forming apparatus **1** according to one embodiment of this patent specification.

As shown in FIG. **2**, the image forming apparatus **1** is a tandem color printer including four imaging stations **4**Y, **4**M, **4**C, and **4**K arranged in series along the length of an intermediate transfer unit **85** to form a toner image of a particular primary color, as designated by the suffixes "Y" for yellow, "M" for magenta, "C" for cyan, and "K" for black, on a recording medium such as a sheet of paper S. A bottle rack **101** is provided in the upper portion of the apparatus **1**, accommodating four removable toner bottles **102**Y, **102**M, **102**C, and **102**K therein from which toner is supplied to the imaging stations **4**Y, **4**M, **4**C, and **4**K, respectively.

Each imaging station (indicated collectively by the reference numeral **4**) includes a motor-driven, cylindrical photoconductor drum **5** having its outer, photoconductive surface surrounded by a charging device **75**, a development device **76**, a cleaning device **77**, and a discharging device, while subjected to light radiation from an exposure device **3**. In the present embodiment, the charging device **75** comprises a contact charger disposed in contact with the photoconductor drum **5**. The development device **76** comprises a non-contact development device disposed out of contact with the photoconductor drum **5**. The cleaning device **77** comprises a brush or blade held in contact with the photoconductor drum **5**.

The intermediate transfer unit **85** includes an intermediate transfer belt **78** entrained around a transfer backup roller **82**, a cleaning backup roller **83**, and a tension roller **84**. In the present embodiment, the intermediate transfer belt **78** comprises an endless looped belt formed of a substrate of resin film or rubber.

A rotary driver may be provided to the transfer backup roller **82**, which imparts torque to the roller **82** to in turn rotate the belt **78** around the belt supporting rollers. Four primary transfer rollers **79**Y, **79**M, **79**C, and **79**K are disposed opposite the photoconductor drums **5**Y, **5**M, **5**C, and **5**K, respectively, via the belt **78** to form four primary transfer nips therebetween. A secondary transfer roller **89** is disposed opposite the transfer backup roller **82** via the belt **78** to form a secondary transfer nip therebetween. Opposite the cleaning backup roller **83** is a belt cleaner **80** for cleaning the belt surface upstream from the primary transfer nips and downstream from the secondary transfer nip.

Disposed adjacent to the intermediate transfer unit **85** is a fixing device **20**, which includes a fuser member **21** and a pressure member **31**, one being heated and the other being pressed against the heated one, to form a fixing nip therebetween. A detailed description of the fixing device **20** and its associated structure will be given later with reference to FIG. **3** and subsequent drawings.

At the bottom of the apparatus **1** lies an input sheet tray **12** for accommodating a stack of recording sheets S, with a feed roller **97** disposed at the outlet of the tray **12** to pick up a recording sheet S from the sheet stack. A pair of registration rollers **98**, a pair of discharge rollers **99**, and other conveyance and guide members together define a sheet conveyance path along which the recording sheet S advances upward toward the intermediate transfer unit **85** and then through the fixing device **20** to finally reach an output sheet tray **100** situated atop the apparatus **1**.

During operation, the photoconductor drum **5** in each imaging station rotates clockwise in the drawing to forward its outer, photoconductive surface to a series of electrophotographic processes, including charging, exposure, development, transfer, and cleaning, in one rotation of the photoconductor drum **5**.

First, the photoconductive surface is uniformly charged by the charging device **75**, followed by the exposure device **3** irradiating the photoconductive surface with a modulated laser beam. The laser exposure selectively dissipates the charge on the photoconductive surface to form an electrostatic latent image thereon according to image data obtained, for example, by scanning an original document or transmitted from an external data source through a network. Then, the latent image is rendered visible through the development device **76**. The toner image thus obtained is forwarded to the primary transfer nip between the primary transfer roller **79** and the photoconductor drum **5**.

At the primary transfer nip, the primary transfer roller **79** is supplied with a bias voltage of a polarity opposite that of the toner on the photoconductor drum **5**. This electrostatically transfers the toner image from the photoconductive surface to an outer surface of the intermediate transfer belt **78**, with a certain small amount of residual toner particles left on the photoconductive surface. As the belt **78** rotates counterclockwise in the drawing, such transfer process occurs sequentially at the four primary transfer nips along the belt travel path, so that toner images of different colors are superimposed one atop another to form a single multicolor image on the surface of the intermediate transfer belt **78**.

After primary transfer, the photoconductive surface enters the cleaning device **77** to remove residual toner mechanically with the cleaning brush or blade, and then to the discharging device to remove residual charges for completion of one imaging cycle. At the same time, the intermediate transfer belt **78** forwards the multicolor image to the secondary transfer nip between the transfer backup roller **82** and the secondary transfer roller **89**.

Meanwhile, in the sheet conveyance path, the feed roller **97** rotates counterclockwise in the drawing to introduce a recording sheet S from the sheet tray **12** toward the pair of registration rollers **98** being rotated. Upon receiving the fed sheet S, the registration rollers **98** stop rotation to hold the incoming sheet S therebetween, and then advance it in sync with the movement of the intermediate transfer belt **78** to the secondary transfer nip. At the secondary transfer nip, the multicolor image is transferred from the belt **78** to the recording sheet S, with a certain small amount of residual toner particles left on the belt surface.

After secondary transfer, the intermediate transfer belt **78** enters the belt cleaner **80**, which removes and collects residual toner from the intermediate transfer belt **78**. At the same time, the recording sheet S bearing the powder toner image thereon is introduced into the fixing device **20**, which fixes the multicolor image in place on the recording sheet S with heat and pressure through the fixing nip.

Thereafter, the recording sheet S is forwarded by the discharge rollers **99** to the output tray **100** for stacking outside the apparatus body, which completes one operational cycle of the image forming apparatus **1**.

Operation of the image forming apparatus **1** may be governed by a system controller, such as a microcomputer including a central processing unit (CPU) combined with a read-only memory (ROM) that stores programs for execution by the CPU, as well as other volatile or non-volatile data storage, such as a random-access memory (RAM) and input/output interface software.

The system controller may be connected with various actuator devices involved in the electrophotographic imaging processes, such as rotary motors or actuators driving the photoconductive drums **5** of the imaging station **4** and the pressure member **31** of the fixing unit **20**, and a power supply for a heater included in the thermal fixing process, as well as various sensors that detect, for example, changes in operational conditions to output detection signals, based on which the controller controls operation of the actuator devices.

An operation panel including various input/output devices, such as keys, buttons, and display monitors, is provided in the image forming apparatus **1** to allow the system controller to communicate information to and from a human operator manipulating the operation panel.

The image forming apparatus **1** described above may be configured as any type of electrophotographic imaging system, such as a photocopier, facsimile machine, printer, plotter, or multifunctional machine incorporating several of those imaging functions. For example, where the image forming apparatus **1** includes a facsimile capability, a dedicated, facsimile output sheet tray may be provided for stacking a recording sheet on which a telecommunicated image is printed according to a facsimile signal sent via a telephone line.

FIGS. **3** and **4** are an end-on, axial view and a top plan view, respectively, of the fixing device **20** incorporated in the image forming apparatus **1** according to one embodiment of this patent specification.

As shown in FIGS. **3** and **4**, the fixing device **20** includes a rotatable, flexible fuser belt **21** looped into a generally cylindrical configuration, a fuser pad **26** extending in an axial, longitudinal direction X thereof inside the loop of the fuser belt **21**, and a pressure member **31** extending in the axial direction X opposite the fuser pad **26** with the fuser belt **21** interposed between the fuser pad **26** and the pressure member **31**. The pressure member **31** presses against the fuser pad **26** through the fuser belt **21** in a load direction Z to form a fixing nip N therebetween, through which a recording medium S is conveyed in a conveyance direction Y.

The pressure member **31** is equipped with an adjustable biasing mechanism, including, for example, a positioning lever **51**, a cam **52**, and an elastic member **53**, which allows positioning the pressure member **31** relative to the fuser belt **21** in the load direction Z to establish the fixing nip N with a desired strength or width in the conveyance direction Y, and to de-establish the fixing nip N where no nip pressure is required. A rotary driver is connected to a shaft of the pressure member **31** via a gear **45** through which torque is imparted to the pressure member **31**.

Also included in the fixing device **20** are a generally cylindrical, tubular heat pipe **22** around which the fuser belt **21** is entrained, a reinforcing member **23** inside the loop of the fuser belt **21** to reinforce the fuser pad **26**, and one or more heaters **25** disposed adjacent to the fuser belt **21** to heat the belt **21**. A pair of inner and outer, retaining stays **70** and **71** are disposed in engagement with the heat pipe **22** to retain the pipe **22** in shape. A temperature sensor **40**, such as a thermometer or a thermistor, is disposed adjacent to the fuser belt **21** to detect a temperature at an outer surface of the belt **21**.

With specific reference to FIG. **4**, the fuser belt **21** and the pressure member **31** are shown extending parallel to each other in the axial, longitudinal direction X between a pair of sidewalls **43**. Components disposed inside the loop of the fuser belt **21**, including the heat pipe **22**, the reinforcing member **23**, the heater **25**, and the fuser pad **26**, also extend generally parallel to each other in the axial direction X.

During operation, the pressure member **31** rotates clockwise in the drawing to in turn cause the fuser belt **21** to rotate counterclockwise in the drawing. Meanwhile, the power circuitry starts supplying electricity to the heater **25**, which then generates heat for conduction to the heat pipe **22** to in turn heat the fuser belt **21**. Power supply to the heater **25** is adjusted according to readings of the temperature sensor **40** to heat the fixing nip N to a given operational temperature.

Then, a recording sheet S bearing an unfixed, powder toner image T enters the fixing device **20** with its front, printed face brought into contact with the fuser belt **21** and bottom face into contact with the pressure member **31**. As the fuser belt **21** and the pressure member **31** rotate together, the recording sheet S moves in the conveyance direction Y through the fixing nip N, where the fuser belt **21** heats the incoming sheet S to fuse and melt the toner particles, while the pressure member **31** presses the sheet S against the fuser pad **26** to cause the molten toner to set onto the sheet surface.

The heat pipe **22** is heated directly through radiation from the heater **25**, so that the fuser belt **21** rotating around the heat pipe **22** is heated indirectly through conduction from the heat pipe **22**. Provision of the heat pipe **22** inside the loop of the fuser belt **21** allows for fast reliable fixing process with a short warm-up time and fast-print time required to execute a print job, while effectively preventing imaging defects caused due to insufficient heating of the fuser belt even where the fixing device operates at a higher processing speed. Moreover, such a heating assembly does not require a complicated structure, leading to a compact configuration of the belt-based fixing device **20**.

In the present embodiment, the fuser belt **21** comprises a thin, flexible endless belt composed of a thermally conductive substrate upon which an intermediate layer of elastic material and an outer layer of release agent are deposited one upon another to form a multilayered structure, approximately 1 mm or smaller in thickness. The fuser belt **21** is looped into a generally cylindrical configuration, approximately 15 mm to approximately 120 mm in diameter, so that the outer layer faces the exterior of the loop and the substrate faces the interior of the loop. For example, the fuser belt **21** may be a looped belt having an outer diameter of approximately 30 mm in its looped, generally cylindrical configuration.

The substrate of the belt **21** may be formed of thermally conductive material, approximately 20 μm to approximately 35 μm thick, including nickel, stainless steel, or any suitable metal, as well as synthetic resin such as polyimide (PI).

The intermediate elastic layer of the belt **21** may be a deposit of rubber, such as solid or foamed silicone rubber, fluorine resin, or the like, approximately 100 μm to approximately 300 μm thick on the substrate **21***a*. The elastic layer serves to accommodate minute variations in applied pressure to maintain smoothness of the belt surface at the fixing nip N, which ensures uniform distribution of heat across a recording sheet S to yield a resulting image with a smooth, consistent appearance.

The outer coating of the belt **21** may be a deposit of a release agent, such as tetra fluoro ethylene-perfluoro alkyl vinyl ether copolymer or PFA, polytetrafluoroethylene (PTFE), polyimide (PI), polyetherimide (PEI), polyethersulfide (PES), or the like, approximately 10 to approximately 50 μm thick on the elastic layer. The coating layer provides good stripping of toner from the belt surface to ensure reliable conveyance of recording sheets S through the fixing nip N.

The one or more heaters **25** each comprises an elongated, radiant heating element, such as a halogen heater or a carbon heater, disposed stationary inside the heat pipe **22** with its opposed longitudinal ends secured to the sidewalls **43** to radiate heat to an inner circumferential surface of the heat pipe **22**. The heater **25** may operate under control of the system controller, which adjusts power supply to the heater **25** to provide adequate radiation to the heat pipe **22**.

The heat pipe **22** comprises a thin-walled pipe formed of thermally conductive material, such as aluminum, iron, stainless steel, or any suitable metal, disposed stationary inside the loop of the fuser belt **21** with its opposed longitudinal ends secured to the sidewalls **43** to face the inner circumferential surface of the fuser belt **21** except at the fixing nip N. Mounting of the heat pipe **22** may be accomplished, for example, using a pair of mounting flanges formed of suitable material, such as resin, provided to the respective longitudinal ends of the heat pipe **22**.

Optionally, the inner circumferential surface of the heat pipe **22** may be coated with a black, thermally absorptive material to increase emissivity of the heat pipe **22**. Such arrangement allows for obtaining high thermal efficiency in heating the fuser belt **21** with the radiant heater **25**.

On one side of the heat pipe **22** (i.e., the side facing the pressure member **31**) is a longitudinal side slot **22***a* into which the fuser pad **26** is inserted with a suitable clearance between the adjoining surfaces of the heat pipe **22** and the fuser pad **26**. The heat pipe **22** has an elongated opening or slit **22***b* along the side slot **22***a* such that the fuser pad **26** accommodated in the side slot **22***a* can contact the reinforcing member **23** inside the heat pipe **22** through the side slit **22***b*.

The longitudinally slotted configuration of the heat pipe **22** allows for efficient heating of the fuser belt **21** over an extended circumferential area where the fuser belt **21** contacts the heat pipe **22** subjected to heating outside the fixing nip N, in particular, upstream from the fixing nip N. Such a heat pipe **22** may be formed, for example, by bending a 0.1-mm thick stainless steel plate into a generally cylindrical configuration with its opposed two longitudinal edges bent or folded twice in the shape of a letter L to form the longitudinal side slot **22***a* and the slit **22***b* between the longitudinal edges.

Thickness of the wall of the heat pipe **22** may be set to a suitable range, for example, no more than 0.2 mm, and preferably, approximately 0.1 mm. The extremely thin-walled heat pipe **22** with a wall thickness of 0.2 mm or less can be heated quickly and sufficiently to in turn heat the fuser belt **21**, leading to high thermal efficiency in the belt-based fixing device **20**.

The heat pipe **22** has its outer diameter dimensioned relative to the inner diameter the fuser belt **21**, so that the fuser belt **21** during rotation adjoins a heated circumferential portion (i.e., upstream from the fixing nip N in the present embodiment) of the heat pipe **22**, at which the heat pipe **22** is internally subjected to radiation from the heater **25**, uninterrupted by the reinforcing member **23** inside the heat pipe **22**.

For example, the fuser belt **21** may be in close proximity with the heated circumferential portion of the heat pipe **22**, with a gap of approximately 0.3 mm or less left between the adjoining surfaces of the belt **21** and the pipe **22**. Alternatively, instead, the fuser belt **21** may establish a direct, sliding contact with the heated circumferential portion of the heat pipe **22** for obtaining higher thermal efficiency in heating the fuser belt **21**. In such cases, to prevent premature abrasion or damage due to increased torque on the sliding surfaces of the belt **21** and the pipe **22**, the fuser belt **21** and the heat pipe **22** is designed to contact each other with a contact pressure of approximately 0.3 kgf/cm^2 or smaller.

Additionally, to protect the fuser belt **21** against abrasion from contact with the heat pipe **22**, a lubricating agent, such as fluorine grease, may be deposited on the outer circumferential surface of the heat pipe **22**. Reducing friction between the fuse belt **21** and the heat pipe **22** may also be accomplished by forming the sliding surface of the heat pipe **22** with a material of low frictional coefficient, or providing a coating layer containing fluorine on the inner circumferential surface of the fuser belt **21**.

Although the heat pipe **22** depicted in FIG. **3** is configured as a generally cylindrical body having a substantially circular cross-section, configuration of the heat pipe **22** may be other than that depicted in the present embodiment, including, for example, a hollow prismatic body having a complex, polygonal cross-section.

The reinforcing member **23** comprises an elongated piece of rigid material, such as iron, stainless steel, or any suitable metal, having a length equal to that of the fuser pad **26**, with its opposed longitudinal ends secured to the sidewalls **43**. Mounting of the reinforcing member **23** may be accomplished, for example, using a pair of mounting flanges, such as the one used to mount the heat pipe **22**.

With additional reference to FIG. **5**, which is a perspective view of the reinforcing member **23** before assembly into the fixing device **20**, the reinforcing member **23** is shown constructed of an elongated beam **23***a* and multiple contact portions **23***b* disposed along the length of the beam **23***a* on a side that faces the fuser pad **26** upon assembly.

The reinforcing member **23** supports pressure from the pressure member **31** through the fuser pad **26** and the fuser belt **21** in the load direction Z, thereby preventing the fuser pad **26** from significant deformation under pressure at the fixing nip N. Providing the reinforcing member **23** with the multiple contact portions **23***b*, as opposed to a single contact portion, allows for equalizing pressure distribution along the length of the fuser pad **26**, leading to good fixing performance with uniform nip pressure across the fixing nip N.

Optionally, the reinforcing member **23** may be at least partially provided with a covering of thermal insulator, or subjected to a bright annealing or mirror polish, where it faces the heater **25** inside the heat pipe **22**. Such arrangement prevents heat from dissipation in the reinforcing member **23**, and thus causes more heat to be imparted to the heat pipe **22**, leading to higher thermal efficiency in heating the fuser belt **21** around the internally heated pipe **22**.

With additional reference to FIG. **6**, which is a perspective view of the heat pipe **22** and the fuser pad **26** before assembly into the fixing device **20**, the pair of inner and outer, retaining stays **70** and **71** is shown assembled with the heat pipe **22**, the former fitting around the side slot **22***a* from inside the heat pipe **22**, and the latter fitting around the side slot **22***a* from outside the heat pipe **22**.

The inner retaining stay **70** comprises an elongated, semi-tubular piece of sheet metal having a rectangular U-shaped cross-section, formed by bending a sheet of stainless steel, approximately 1.5 mm thick. The inner retaining stay **70** may be subjected to bright annealing or mirror polish where it faces the heater assembly, which allows for efficient heating of the heat pipe **22** through radiation from the heaters **25**.

The outer retaining stay **71** comprises an elongated, semi-tubular piece of sheet metal having a rectangular U-shaped cross-section. The fuser pad **26** is disposed inside the outer retaining stay **71** with a clearance left between the adjoining surfaces of the fuser pad **26** and the retaining stay **71**. The outer retaining stay **71** may be formed into a box-like, closed-end configuration, instead of a semi-tubular rectangular configuration, which can effectively restrict displacement of the fuser pad **26** in the directions perpendicular to the conveyance direction Y.

During assembly, the inner and outer retaining stays **70** and **71** are disposed on the opposed L-shaped bent edges of the heat pipe **22**, such as a 0.1-mm thick stainless steel plate bent into a generally cylindrical configuration, the former from inside and the latter from outside the heat pipe **22**. The stays **70** and **71** are then fastened in place, for example, using screws. The heat pipe **22** thus having its opposed L-shaped bent edges clamped together can maintain its generally cylindrical configuration.

Provision of the retaining stays **70** and **71** allows for high precision and stability in the shape of the side slot **22***a* of the heat pipe **22**, which in turn allows for formation of the fixing nip N in parallel alignment with the recording sheet S advanced in the conveyance direction Y so that the fuser belt **21** can closely contacts the recording sheet S throughout the fixing nip N, leading to reliable imaging performance of the fixing device **20**.

Additionally, the inner retaining stay **70** may have one or more through-holes **70***a* defined where it faces the slit **22***b* of the heat pipe **22**, for passing therethrough the contact portion **23***b* of the reinforcing member **23**. Likewise, the outer retaining stay **71** may have one or more through-holes **71***a* defined where it faces the slit **22***b* of the heat pipe **22**, for passing therethrough the contact portion **23***b* of the reinforcing member **23**.

The number of the through-holes in each retaining stay is equal to that of the contact portions **23***b* of the reinforcing member **23** (e.g., five in the present embodiment), and the size of the through-holes in each retaining stay is larger than that of the contact portions **23***b*. The through-holes **70***a* and **71***a* are aligned with each other, such that each contact portion **23***b* of the reinforcing member **23** can extend through the aligned through-holes **70***a* and **71***a* to contact the fuser pad **26** in the side slot **22***a* of the heat pipe **22**.

With continued reference to FIGS. **3** and **4**, the pressure member **31** is shown comprising a generally cylindrical roller formed of a hollow, cylindrical core **32** of metal, covered with an elastic layer **33** of thermally insulating material, such as sponged or solid silicone rubber, fluorine rubber, or the like. An additional, thin outer layer of release agent, such as PFA, PTFE, or the like, may be deposited upon the elastic layer **33**. In the present embodiment, the pressure roller **31** is approximately 30 mm in diameter.

The elastic layer **33** of the pressure roller **31** may be formed of a sponged material, such as sponged silicone rubber. Such an elastic layer **33** effectively absorbs extra pressure applied to the fuser pad **26** from the pressure roller **31**, which protects the fuser pad **26** against deformation under nip pressure. The sponged elastic layer **33** also serves as an insulator that prevents heat conduction from the fuser belt **21** toward the pressure roller **31**, leading to high thermal efficiency in heating the fuser belt **21** in the fixing device **20**.

A pair of bearings **42** is provided to the longitudinal ends of the pressure roller **31**, which rotatably holds the roller **31** in position onto the sidewalls **43** of the fixing device **20**. Optionally, the pressure roller **31** may have a dedicated heater, such as a halogen heater, accommodated in the hollow interior of the metal core **32**.

The fuser pad **26** comprises an elongated, substantially rectangular piece of heat-resistant elastic material, such as liquid crystal polymer (LCP), PI, polyamide-imide (PAI), disposed stationary inside the loop of the fuser belt **21** with its opposed longitudinal ends secured to the sidewalls **43** to receive pressure from the pressure member **31**.

With additional reference to FIG. **7**, which is another perspective view of the fuser pad **26**, the fuser pad **26** is shown including an elongated body **26***a* with one or more support projections **26***b* extending from the elongated body **26***a*.

Upon assembly, the fuser pad **26** is disposed with the elongated body **26***a* facing the pressure member **31** and the support projections **26***b* facing the reinforcing member **23**. The elongated body **26***a* of the fuser pad **26** serves to receive pressure from the pressure roller **31** via the fuser belt **21** in the load direction Z. The support projections **26***b* serve to contact the contact portions **23***b* of the reinforcing member **23** extending from inside the heat pipe **22** through the slit **22***b*, such that the fuser pad **26** maintains its proper operational shape and position in the load direction Z under pressure from the pressure roller **31**.

The multiple support projections **26***b* may have an identical thickness in the load direction Z. Alternatively, instead, the multiple support projections **26***b* may have different thicknesses in the load direction Z depending on the position along the length of the fuser pad **26**, so that the one at the longitudinal center is the longest and those at the longitudinal ends are the shortest of all the projections **26***b*. Varying the size of the projections **26***b* allows for effectively equalizing nip pressure along the length of the fuser pad **26**, leading to good fixing performance with uniform nip pressure across the fixing nip N.

Optionally, a covering **29** of anti-friction material, such as a web or mesh of PTFE fibers or fluorine-coated glass fibers, may be wound around the elongated body **26***a*, with a perforated attachment **19** fitted around the projections **26***b* and screwed onto the elongated body **26***a* to secure the covering **29** in position. Provision of the anti-friction covering **29** allows for reducing friction between the fuser pad **26** and the fuser belt **21**.

With continued reference to FIG. **3**, the fixing device **20** is shown further including a sheet or media stripper **27** disposed downstream from the fixing nip N in the conveyance direction Y to define an elongated, longitudinal edge **27***a* extending in the axial direction X while positioned adjacent to and apart from the fuser belt **21** to separate the recording sheet S from the fuser belt **21** upon exit from the fixing nip N.

The sheet stripper **27** comprises an elongated structure formed of one or more pieces of material, with its longitudinal edge **27***a* formed in any suitable shape, including, for example, a straight linear edge, a curved edge, a serrated or stepped edge, or any combination thereof, to separate, or assist in separating, the recording sheet S from the fuser belt **21**. The media stripper **27** may be hinged for rotation around its rotational axis extending in the axial direction X.

Additionally, an auxiliary sheet or media stripper **34** may be disposed downstream from the fixing nip N in the conveyance direction Y to define an elongated, longitudinal edge extending in the axial direction X while positioned adjacent to and apart from the pressure roller **31** to separate the recording sheet S from the pressure roller **31** upon exit from the fixing nip N.

The auxiliary sheet stripper **34** comprises an elongated guide plate with its longitudinal edge formed in any suitable shape to separate, or assist in separating, the recording sheet S from the pressure roller **31**. Provision of the auxiliary media stripper **34** is effective particularly during duplex printing where the recording sheet S tends to wind around the pressure roller **31** due to adhesion of the toner image previously fixed on the first printed side of the recording sheet S.

FIG. **8** is a side elevational view of the fuser pad **26**.

As shown in FIG. **8**, the fuser pad **26** includes an upstream section A**1**, a midstream section A**2**, and a downstream section A**3** arranged in series from upstream to downstream in the conveyance direction Y, each of which defines a specially shaped surface for facing the pressure roller **31** upon assembly.

Specifically, with additional reference to FIG. **9**, which is another end-on, axial view of the fixing device **20**, shown with the fuser belt **21** omitted for clarity, the upstream section A**1** defines a generally planar surface along which the recording medium S is introduced into the fixing nip N; the midstream section A**2** defines an inwardly curved, concave surface that conforms to an outer circumferential surface of the pressure roller **31**; and the downstream section A**3** defines a protruding surface that protrudes outward toward the pressure roller **31** while located apart from the pressure roller **31**.

Providing the fuser pad **26** with the differently shaped surfaces from upstream to downstream in the conveyance direction Y effectively prevents image defects due to insufficient heat and pressure through the fixing nip N, while allowing good separation of the recording medium S from the fuser belt **21**.

In particular, provision of the downstream section A**3** defining a protruding surface in combination with the midstream section A**2** defining an inwardly curved, concave surface, as opposed to a flat, planar surface, results in a sufficiently small gap between the fuser belt **21** and the recording medium **5**, translating into a sufficient heat and pressure applied to the recording medium S, even where the leading edge of the recording medium S reaches the protruding surface which would direct the outgoing sheet S away from the fuser belt **21** toward the pressure roller **31**.

Moreover, deploying the protruding surface of the downstream section A**3** apart from the pressure roller **31** prevents undesired winding or wrapping of the recording medium S around the pressure roller **31** as well as improper extension of the fixing nip N in the conveyance direction Y, which would occur where the protruding surface of the downstream section A**3** accidentally contacts the pressure roller **31**.

More specifically, in the present embodiment, the upstream section A**1** extends over an area overlapping and immediately upstream from the fixing nip N. Upon entry into the fixing nip N after passing through the secondary transfer nip defined between the backup roller **82** and the secondary transfer roller **89**, the recording sheet S conveyed along the generally planar surface of the upstream section A**1** can maintain its generally flat, planar configuration without bending or deformation.

The midstream section A**2** extends over an area overlapping and immediately downstream from the fixing nip N. With the inwardly curved, concave surface of the midstream section A**2**, the recording sheet S passing through the fixing nip N can closely contact the fuser belt **21** under pressure from the pressure roller **31**.

The downstream section A**3** extends over an area downstream from the fixing nip N. The protruding surface of the downstream section A**3** causes the fuser belt **21** to assume a greater curvature at the exit of the fixing nip N than within the fixing nip N, which ensures the recording sheet S separates from the fuser belt **21** even in the presence of adhesion between fused toner and belt surfaces. Alternatively, instead of or in addition to facilitating sheet separation from the fuser belt **21**, the protruding surface of the downstream section A**3** may be configured to bend the recording sheet S away from the fuser belt **21** to prevent curling of the recording sheet S upon exit from the fixing nip N.

Further, in the present embodiment, a relieved edge A**0**, such as a chamfered or rounded edge, is provided immediately upstream from the upstream section A**1** in the conveyance direction Y. For example, the relieved edge may be a chamfered edge that extends, for example, approximately 0.5 mm from the generally planar surface of the upstream section A**1**.

The relieved edge A**0** of the fuser pad **26**, together with the adjoining edge of the side slot **22***a* of the heat pipe **22**, form a substantially continuous surface along which the fuser belt **21** smoothly passes from the heat pipe **22** to the fuser pad **26**. Such arrangement prevents the fuser belt **21** from damage and premature failure due to bending upon contacting the fuser pad **26**, while allowing the heat pipe **22** to reliably contact and slide against the fuser belt **21** to heat the belt **21** sufficiently immediately upstream from the fixing nip N, leading to high thermal efficiency in the belt-based fixing device **20**.

For comparison purposes, consider a configuration in which the fuser pad **26** has a perpendicular edge, instead of a chamfered or rounded edge, adjoining the edge of the side slot **22***a* of the heat pipe **22**. In such cases, presence of the perpendicular edge creates a gap or unevenness between the adjoining surfaces of the heat pipe **22** and the fuser pad **26**, which cause the fuser belt **21** to bend and elevate away from contact with the heat pipe **22** upstream from the fixing nip N, resulting in damage and premature failure of the belt material as well as insufficient heating of the fuser belt **21** before entering the fixing nip N.

Furthermore, in the present embodiment, the inwardly curved, concave surface of the midstream section A**2** has a constant radius of curvature ranging from approximately 25 mm to approximately 60 mm. For a good conformity between the adjoining surfaces of the midstream section A**2** and the pressure roller **31**, the radius of curvature may be adjusted depending on the diameter of the pressure roller **31**. For example, where the diameter of the pressure roller **31** is set to 30 mm, the radius of curvature of the midstream section A**2** is set to 60 mm.

The upstream end of the midstream section A**2**, coextensive with the downstream end of the upstream section A**1**, may be any point within the fixing nip N, which is determined with respect to a center Nc of the fixing nip N in the conveyance direction Y. In the present embodiment, the upstream end of the midstream section A**2** is located downstream from the center Nc of the fixing nip N, so that the upstream section

A1 encompasses a broader area within the fixing nip N than that of the midstream section A2.

Positioning of the upstream end of the midstream section A2 may be other than that described in FIG. 9, such as upstream from, or coincident with the center Nc of the fixing nip N, depending on the specific configuration.

Still further, in the present embodiment, the downstream section A3 is contiguous to, and immediately downstream from, the midstream section A2 in the conveyance direction Y. The protruding surface of the downstream section A3 may have a vertex V thereof lying on an imaginary curve C2 concentric to, and smaller in radius than, an imaginary curve C1 with which the inwardly curved surface of the midstream section A2 coincides.

In such cases, a distance L_1, in a radial direction of the imaginary curves C1 and C2, between the inwardly curved surface of the midstream section A2 and the vertex V of the downstream section A3 (i.e., a difference in radius between the imaginary curves C1 and C2) may fall within a range between approximately 0.1 mm to approximately 0.2 mm. In addition, a distance L_2, in the conveyance direction Y of the recording sheet S, between a downstream end of the fixing nip N and the vertex V of the downstream section A3 may fall within a range between approximately 1 mm to approximately 2 min.

Setting the distance L_1 between approximately 0.1 mm to approximately 0.2 mm and the distance L_2 between approximately 1 mm to approximately 2 mm allows for proper operation of the fixing device without causing variations in nip pressure or winding of recording medium around the fixing members.

For example, setting the distance L_2 below 1 mm can cause variations in pressure across the fixing nip N, in which interference between the downstream section A3 and the pressure roller 31 causes the midstream section A2 of the fuser pad 26 to partly come off the outer circumferential surface of the pressure roller 31, resulting in a locally reduced area of contact between the fuser pad 26 and the pressure roller 31 within the fixing nip N. Such variations in contact between the fixing members can translate into variations in pressure with which a toner image is processed through the fixing nip N, leading to concomitant print defects, such as orange-peel effects, in the resulting image.

Setting the distance L_2 above 2 mm and/or setting the distance L_1 above 0.2 mm can cause the recording sheet S to wind around the pressure roller 31, in which interference between the downstream section A3 and the recording sheet S causes the sheet S to bend and deflect away from the fuser pad 26 to eventually wrap around the outer circumferential surface of the pressure roller 31 upon exiting the fixing nip N.

This is particularly true during duplex printing, in which the recording sheet S enters the fixing nip N with a first, previously printed side facing the pressure roller 31 and a second, unfixed side facing the fuser belt 21, which causes toner once fixed on the first side to soften and become adhesive to the pressure roller 31 due to heat within the fixing nip N.

Setting the distance L_1 below 0.1 mm increases the risk of winding the recording sheet S around the fuser belt 21, in which the downstream section A3 fails to properly separate the recording sheet S from the fuser belt 21, causing the outgoing sheet S to eventually wrap around the circumferential surface of the belt 21 at the exit of the fixing nip N.

Thus, setting the distances L_1 and L_2 to the appropriate ranges prevents undue interference between the fuser pad 26 and the pressure roller 31 as well as between the recording sheet S and the fixing members, leading to reliable fixing performance of the fixing device 20.

Yet still further, in the present embodiment, the protruding surface of the downstream section A3 forms a circular arc in cross section. That is, the protruding surface may be an outwardly curved surface with a constant radius of curvature, which is tangent to both the imaginary curve C2 and an imaginary plane B passing through a downstream end of the fuser pad 26 and perpendicular to the conveyance direction Y. Such arrangement prevents the recording sheet S from excessively bending around the downstream section A3, and allows for ready separation of the recording sheet S from the fuser belt 21 upon exiting the fixing nip N.

FIG. 10 is a schematic view of the pressure member 31 before assembly into the fixing device 20.

As shown in FIG. 10, the pressure member 31 comprises a concave roller whose diameter gradually increases by a first amount of taper T_1 from a longitudinal center toward both longitudinal ends thereof in the axial direction X.

The concave configuration of the pressure member 31 allows for equalizing temperature distribution in the longitudinal direction X across the fixing nip N, where heat dissipates to the air at the longitudinal edges of the concave roller 31, leading to stabilized performance of the fixing device.

With additional reference to FIGS. 11A and 11B, the fuser pad 26, the pressure roller 31, and the reinforcing member 23 are shown in their respective positions with the fuser belt 21 omitted for clarity, where no pressure exists between the pressure roller 31 and the fuser pad 26 (FIG. 11A), and where the pressure roller 31 exerts pressure against the fuser pad 26 (FIG. 11B).

As shown in FIGS. 11A and 11B, the downstream section A3 of the fuser pad 26 has a thickness in the load direction Z which gradually increases by a second amount of taper corresponding to the first amount of taper T_1, from a longitudinal center toward both longitudinal ends thereof in the axial direction X.

As used herein, the term "taper" refers to a gradual increase in length or thickness in the load direction Z from a longitudinal center toward opposed longitudinal ends of an elongated structure extending in the axial direction X, such as the pressure member 31 and the fuser pad 26. For example, such tapering may be provided symmetrically with respect to the longitudinal center of the elongated structure. The term "amount of taper" refers to a difference in length or thickness in the load direction Z between the longitudinal center and longitudinal end of the tapered, elongated structure. Additionally, the term "longitudinal center" is used to describe a central portion generally equidistant from opposed extreme edges of the elongated structure, which includes, but is not limited to, the precise longitudinal center of the elongated structure. The term "longitudinal end" is used to describe an end portion extending from one extreme edge of the elongated structure, which includes, but is not limited to, the precise longitudinal end of the elongated structure.

In the present embodiment, the first amount of taper may be defined, for example, as a difference between an average of diameters at the longitudinal ends and a diameter at the longitudinal center of the pressure member across a given width, as given by the following equation:

$$T_1=(Zb+Zc)/2-Za \qquad \text{Equation I}$$

where "T_1" is the first amount of taper in mm, "Za" is the roller diameter in mm at the longitudinal center, "Zb" is the roller diameter in mm at one longitudinal end, and "Zc" is the roller diameter at the other longitudinal end.

The width across which the roller diameters are measured may be defined as the total of a maximum width of recording medium accommodated in the fixing device and a given additional width of, for example, 10 mm (5 mm each side).

The inventor has recognized that one problem encountered when employing a concave pressure roller in combination with a fuser pad that has an integral, protruding surface at a downstream section thereof for facilitating separation of the recording medium and/or for correcting curl on the recording medium is malfunction of the media stripper downstream from the fixing nip due to deformation of the fuser pad under pressure from the pressure roller.

With reference to FIG. **12**, an exemplary fixing device is shown including a fuser pad **226** and a concave pressure roller **231** pressing against the fuser pad **226** via a fuser belt **221** to form a fixing nip therebetween through which a recording sheet is conveyed, as well as a sheet stripper defining a longitudinal edge **227***a* for separating the sheet from the fuser belt **221** downstream from the fixing nip.

As shown in FIG. **12**, the fuser pad **226** bends or deforms under pressure form the concave pressure roller **231**, causing the fuser belt **121** to assume a convex shape curving away from the axial, longitudinal direction of the fuser pad **226**.

On one hand, deformation of the fuser pad **226** allows the fuser belt **221** to contact the pressure roller **231** closely and uniformly across the fixing nip. Uniform contact between the fuser belt **221** and the pressure roller **231** translates into uniform, sufficient heat and pressure applied to the recording sheet through the fixing nip, leading to stable fixing and glossing performance of the fixing device.

On the other hand, however, the fuser pad **226** thus deformed does not properly align with the longitudinal edge **227***a* of the sheet stripper, which is normally designed to extend in the longitudinal direction of the fuser pad **226**. Misalignment between the fuser pad **226** and the sheet stripper edge **227***a* results in different sizes of gap by which the recording sheet is spaced apart from the adjoining surfaces of the fuser belt and the sheet stripper, making it difficult for the sheet stripper edge **227***a* to properly engage the recording sheet for stripping it away from the fuser belt **221**.

These and other problems are effectively addressed by the fixing device **20** according to this patent specification, owing to provision of the downstream section A**3** of the fuser pad **26** which is tapered in the axial direction X by an amount corresponding to that of the concave pressure roller **31**.

Specifically, in the present embodiment, the downstream section A**3** of the fuser pad **26** is concave away from the pressure member **31** in its original, unloaded state (FIG. **11**A), and is flat facing the pressure member **31** in its operational, loaded state (FIG. **11**B).

As used herein, the term “unloaded state” refers to an original condition or shape assumed where the fuser pad **26** is free from pressure from the pressure member **31**. The term “loaded state” refers to an operational condition or shape assumed where the fuser pad **26** is subjected to pressure from the pressure member **31**.

As mentioned earlier, the fixing device **20** in the present embodiment is provided with the sheet or media stripper **27** disposed downstream from the fixing nip N in the conveyance direction Y to define an elongated, longitudinal edge **27***a* extending in the axial direction X while positioned adjacent to and apart from the fuser belt **21** to separate the recording medium S from the fuser belt **21** upon exit from the fixing nip N. In such cases, the downstream section A**3** of the fuser pad **26**, in its operational, loaded state, generally parallels the longitudinal edge **27***a* of the media stripper **27**, as shown in FIG. **13**.

Thus, in the fixing device **20**, tapering the downstream section A**3** of the fuser pad **26** in its original, unloaded state enables the downstream section A**3** in its operational, loaded state to align with the longitudinal edge **27***a* of the sheet stripper **27** extending in the longitudinal direction X of the fuser pad **26**. Proper alignment between the downstream section A**3** of the fuser pad **26** and the sheet stripper edge **27***a* results in a uniform size of gap by which the recording sheet S is spaced apart from the adjoining surfaces of the fuser belt **21** and the sheet stripper **27**, which ensures the sheet stripper edge **27***a* properly engages the recording sheet S for stripping it away from the fuser belt **21**.

With continued reference to FIGS. **11**A and **11**B, the fixing device **20** in the present embodiment is shown provided with the one or more support projections **26***b* integrally disposed on the fuser pad **26** on a side opposite that facing the pressure member **31** to reinforce the fuser pad **26** in the load direction Z. In the present embodiment, the support projections **26***b* comprise a plurality of separate projections arranged in series in the axial direction X. Alternatively, instead, the support projections **26***b* may be configured as a single elongated continuous projection extending in the axial direction X.

As shown in FIGS. **11**A and **11**B, the support projections **26***b* of the fuse pad **26** have a thickness in the load direction Z which gradually increases by a third amount of taper T_3, corresponding to the first amount of taper T_1, from both longitudinal ends toward a longitudinal center thereof in the axial direction X.

In such a configuration, the support projections **26***b*, when subjected to pressure from the pressure roller **31**, become flush against the contact portions **23***b* of the reinforcing member **23**, while thrusting toward the pressure roller **31** deeper at the longitudinal center than at the longitudinal ends thereof, allowing the downstream section A**3** of the fuser pad **26** to be flat facing the pressure roller **31** in its operational, loaded state.

More specifically, in the present embodiment, the third amount of taper is given by the following equation:

$$T_3 = T_1 + k/L \qquad \text{Equation II}$$

where “T_1” is the first amount of taper, “T_3” is the third amount of taper, “L” is a length of the fuser pad in the axial direction X, and “k” is an adjustable value approximately half a maximum width of the recording medium S.

The length L of the fuser pad **26** may be equal to that of the reinforcing member **23**. The variable k may be adjusted depending on a specific configuration of the fixing device **20**, such as material of the stay.

Further, the second amount of taper is given by the following equation:

$$T_2 = T_3 + 0.2 \qquad \text{Equation III}$$

where “T_2” is the second amount of taper in mm, and “T_3” is the third amount of taper in mm.

In the present embodiment, the first amount of taper T_1 is in the range of 0.1 to 0.2 mm, the fuser pad has a length L of 350 mm in the axial direction, and the constant variable k is set to 140 where the maximum width of recording medium is 297 mm corresponding to the longer edge of A4 size paper. Substituting these values T_1, L, and k into Equations II and III gives the second amount of taper T_2 ranging from 0.5 to 0.6 mm, and the amount of taper T_3 ranging from 0.3 to 0.4 mm, respectively.

In further embodiment, at least one of the upstream and midstream sections A**1** and A**2** of the fuser pad **26** may have a thickness in the load direction Z which gradually increases by the second amount of taper T_2 from a longitudinal center toward both longitudinal ends thereof in the axial direction X.

For example, the midstream section A**2** of the fuser pad **26** may have a thickness in the load direction which gradually increases by the second amount of taper T_2 from a longitudinal center toward both longitudinal ends thereof in the axial direction X. The midstream section A**2** of the fuser pad **26** may be concave away from the pressure member **31** in its original, unloaded state, and flat facing the pressure member **31** in its operational, loaded state. In such cases, the midstream section A**2** of the fuser pad **26** generally parallels the longitudinal edge of the media stripper in its operational, loaded state.

Note that, in contrast to the midstream and downstream sections A**2** and A**3**, the upstream section A**1** of the fuser pad **26**, which has a generally uniform thickness in the load direction throughout an entire length of the fuser pad **26** in the axial direction X, is convex toward the pressure member **31** in its operational, loaded state, with an offset or difference d in position in the load direction Z between the longitudinal center and the longitudinal ends thereof, as shown in FIG. **11**B.

Compared to a configuration in which tapering is provided only to the downstream section A**3**, tapering each of the midstream and downstream sections A**2** and A**3** of the fuser pad **26** to generally parallel the longitudinal edge **27***a* of the sheet stripper **27** in its operational, loaded state more reliably ensures that the recording sheet S is positioned in parallel alignment with the longitudinal edge **27***a* of the sheet stripper **27**, leading to more effective sheet stripping performance.

Also, with the upstream section A**1** of the fuser pad **26** being convex toward the pressure member **31** in its operational, loaded state, the fuser belt **21** and the pressure member **31** can closely and uniformly contact each other across the fixing nip N, which translates into uniform, sufficient heat and pressure applied to the recording sheet S through the fixing nip N, leading to stable fixing and glossing performance of the fixing device **20**.

Hence, the fixing device **20** according to this patent specification provides stable fixing and glossing performance while effectively addressing problems encountered when employing a concave pressure roller in combination with a fuser pad that has an integral, protruding surface at a downstream section thereof for facilitating separation of the recording medium and/or for correcting curl on the recording medium.

In particular, malfunction of the sheet stripper downstream from the fixing nip due to deformation of the fuser pad under pressure from the pressure roller is effectively prevented, wherein tapering the downstream section A**3** of the fuser pad **26** in the axial direction X by an amount corresponding to that of the concave pressure roller **31** allows for good alignment between the fuser pad **26** and the sheet stripper edge **27***a* downstream from the fixing nip N without compromising uniform contact between the fuser belt **21** and the pressure roller **31** within the fixing nip N.

Numerous additional modifications and variations are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the disclosure of this patent specification may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A fixing device comprising:

a rotatable, flexible fuser belt looped into a generally cylindrical configuration;

a fuser pad extending in an axial, longitudinal direction thereof inside the loop of the fuser belt; and

a pressure member extending in the axial direction opposite the fuser pad with the fuser belt interposed between the fuser pad and the pressure member,

the pressure member pressing against the fuser pad through the fuser belt in a load direction to form a fixing nip therebetween, through which a recording medium is conveyed in a conveyance direction,

the fuser pad including an upstream section, a midstream section, and a downstream section arranged in series from upstream to downstream in the conveyance direction,

the upstream section defining a generally planar surface along which the recording medium is introduced into the fixing nip, a portion of the upstream section being located apart from the pressure member,

the downstream section defining a protruding surface that protrudes outward toward the pressure member while located apart from the pressure member,

wherein the pressure member comprises a concave roller whose diameter gradually increases by a first amount of taper from a longitudinal center toward both longitudinal ends thereof in the axial direction,

the downstream section of the fuser pad has a thickness in the load direction which gradually increases by a second amount of taper, corresponding to the first amount of taper, from a longitudinal center toward both longitudinal ends thereof in the axial direction,

one or more support projections integrally disposed on the fuser pad on a side opposite that facing the pressure member to reinforce the fuser pad in the load direction, and

the support projections having a thickness in the load direction which gradually increases by a third amount of taper, corresponding to the first amount of taper, from both longitudinal ends toward a longitudinal center thereof in the axial direction.

2. The fixing device according to claim **1**, wherein the downstream section of the fuser pad is concave away from the pressure member in its original, unloaded state, and is flat facing the pressure member in its operational, loaded state.

3. The fixing device according to claim **1**, further comprising:

a media stripper disposed downstream from the fixing nip in the conveyance direction to define an elongated, longitudinal edge extending in the axial direction while positioned adjacent to and apart from the fuser belt to separate the recording medium from the fuser belt upon exit from the fixing nip,

wherein the downstream section of the fuser pad generally parallels the longitudinal edge of the media stripper in its operational, loaded state.

4. The fixing device according to claim **1**, wherein the third amount of taper is given by the following equation:

$$T_3 = T_1 + k/L$$

where "T_1" is the first amount of taper in mm, "T^3" is the third amount of taper in mm, "L" is a length of the fuser pad in the axial direction, and "k" is an adjustable value approximately half a maximum width of the recording medium.

5. The fixing device according to claim **4**, wherein the second amount of taper is given by the following equation:

$$T_2 = T_3 + 0.2$$

where "T_2" is the second amount of taper in mm, and "T_3" is the third amount of taper in mm.

6. The fixing device according to claim **1**, wherein at least one of the upstream and midstream sections of the fuser pad has a thickness in the load direction which gradually increases by the second amount of taper from a longitudinal center toward both longitudinal ends thereof in the axial direction.

7. The fixing device according to claim **6**, wherein the at least one of the upstream and midstream sections of the fuser pad is concave away from the pressure member in its original, unloaded state, and is flat facing the pressure member in its operational, loaded state.

8. The fixing device according to claim **6**, further comprising:

a media stripper disposed downstream from the fixing nip in the conveyance direction to define an elongated, longitudinal edge extending in the axial direction while positioned adjacent to and apart from the fuser belt to separate the recording medium from the fuser belt upon exit from the fixing nip,

wherein the at least one of the upstream and midstream sections of the fuser pad generally parallels the longitudinal edge of the media stripper in its operational, loaded state.

9. The fixing device according to claim **1**, wherein the downstream section of the fuser pad is contiguous to, and immediately downstream from, the midstream section of the fuser pad in the conveyance direction.

10. The fixing device according to claim **1**, wherein the protruding surface of the downstream section forms a circular arc in cross section.

11. The fixing device according to claim **1**, wherein the inwardly curved surface of the midstream section exhibits a constant radius of curvature ranging from approximately 25 millimeters to approximately 60 millimeters.

12. The fixing device according to claim **1**, wherein the protruding surface of the downstream section has a vertex thereof lying on an imaginary curve concentric to, and smaller in radius than, an imaginary curve with which the inwardly curved surface of the midstream section coincides.

13. The fixing device according to claim **12**, wherein a distance, in a radial direction of the imaginary curves, between the inwardly curved surface of the midstream section and the vertex of the downstream section falls within a range between approximately 0.1 mm to approximately 0.2 mm.

14. The fixing device according to claim **12**, wherein a distance, in the conveyance direction of the recording medium, between a downstream end of the fixing nip and the vertex of the downstream section falls within a range between approximately 1 mm to approximately 2 mm.

15. The fixing device according to claim **1**, wherein the fuser belt is formed of a substrate of nickel or stainless steel.

16. An image forming apparatus incorporating the fixing device according to claim **1**.

17. The fixing device according to claim **1**, wherein the midstream section has a constant radius of curvature defining an inwardly curved concave surface that conforms to an outer circumferential surface of the pressure member.

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